IN SEARCH OF AN ELUSIVE ANTARCTIC CIRCUMPOLAR WAVE IN SEA ICE EXTENTS: 1978-1996

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Abstract

For ease in discerning an Antarctic circumpolar wave in the perimeter of the ice pack, we construct a time series of the sea ice extents (essentially the area within the ice perimeter) in 1-degree longitudinal sectors for the period 1978 - 1996, as observed with the multichannel microwave imagers on board the NASA Nimbus 7 and the DOD DMSP F8 , F11, and F13 satellites. After converting the time series into complex numbers by means of a Hilbert transform, we decompose the time series of the 360 sectors into its complex principal components (CPCs), effectively separating the spatial and temporal values. Then we decompose the real and imaginary parts of the temporal portions of the first 3 CPCs by Empirical Mode Decomposition into their intrinsic modes, each representing a narrow frequency band, resulting in a collection of 3 CPCs for each intrinsic mode. Finally, we reconstruct the data in two different ways. First, we low-pass filter the data by combining all of the intrinsic modes of each CPC with periods longer than 2 years, which we designate as lp-filtered. Next, we select the intrinsic mode of each CPC with periods of approximately 4 years, which we designate the quasiquadrennial (QQ) modes. The lp-filtered time series shows eastward-propagating azimuthal motion in the Ross and Weddell Seas, but no clearly circumpolar motion. The QQ time series, on the other hand, clearly shows eastward-propagating circumpolar waves, but with occasional retrograde motion to the west.

Discussion:

White & Peterson [1996] have reported eastward propagation of a circumpolar wave in sea ice extents, as well as in sea level pressures, and sea surface winds and temperatures. The data were preprocessed by passing through a band-pass filter with admittance from 3 to 7 years. They analyzed sea ice extents in 5° meridional sectors, and the other parameters along the 56°S parallel. They interpreted the contour patterns on their resulting position, time diagrams as circumpolar waves propagating eastwards and completing the circular traverse in about a decade (White, *priv. comm.*). Thus the low-pas filter procedure we report here should encompass the entire oscillatory behavior band-passed through their filter.

Our initial motive in undertaking this investigation was to confirm and examine in detail the circumpolar wave in sea ice extents reported by White & Peterson [1996]. However, our sea ice extent results obtained with our lp filter do not agree with theirs. We surmise that their binning of the sea ice extents into 5° sectors, limiting the spatial resolution to about 10° of longitude, may have bridged the "barrier" between 120-150° that we observe in our lp-filtered results. Alternatively, the high frequency end of their band-pass filter, a half-power point of 3 years, may suppress part of the signal admitted by our lp-filter. Certainly, when we eliminate oscillations of 3 years or less with our QQ filter, our results are much more in agreement (Figure 1.).

The results we present here clearly demonstrate the necessity of using a complex number representation of the time series in order to retain the circumpolar motion in the sea-ice pack when applying singular value decomposition. Our earlier attempt at observing the circumpolar motion with real numbers was not successful. The results demonstrate also that care must be used in selecting the appropriate filters and the need for high spatial resolution in order not to lose important details in the wave propagation. Finally, we demonstrate that it is imprudent to presume that complex principal components in themselves represent fundamental modes of an oscillatory system. For instance, the 1st CPC shown here could easily be mistaken by inspection for the season cycle. While it is true that the seasonal cycle is the largest oscillatory component of the 1st CPC, we have shown that the 1st CPC also has 7 other significant oscillatory modes.

We intend to apply this technique also to the interior of the ice pack and to nearby sea surface temperatures and winds in an attempt to elucidate our present observations.

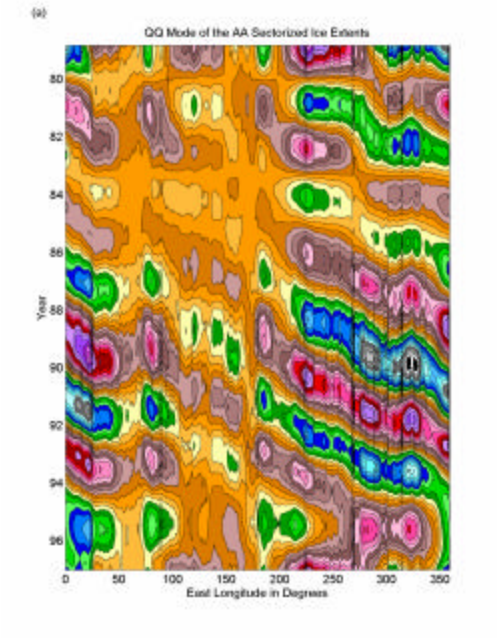

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Figure 1. Circumpolar waves in the sectorized sea ice extents around Antarctica, obtained by selecting the quasibiennial mode from the intrinsic modes obtained by applying Empirical Mode Decomposition to the first five complex principal components of the data